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Cataract Creek  
Dam, Pony,  
Montana, Madison  
County, MT-5

14

PHASE I INSPECTION REPORT  
NATIONAL DAM SAFETY PROGRAM

**CATARACT CREEK DAM  
PONY, MONTANA  
MADISON COUNTY  
MT-5**

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PREPARED FOR:

HONORABLE THOMAS L. JUDGE  
GOVERNOR, STATE OF MONTANA

STATE OF MONTANA  
(OWNER)  
CATARACT WATER USERS ASSOCIATION  
(OPERATOR)

PREPARED BY:  
CH2M HILL  
BELLEVUE, WASHINGTON

APRIL 1980

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## EXECUTIVE SUMMARY

Under contract with the Seattle District Corps of Engineers, and with representation from the Corps and the State of Montana Department of Natural Resources and Conservation (DNRC), CH2M HILL inspected Cataract Creek Dam on May 21, 1979, under the authority of Public Law 92-367. The dam is located on Cataract Creek in Madison County about 2 miles southwest of Pony, Montana.

This report was compiled from information obtained during an onsite inspection, review of construction plans and specifications, and analysis of available hydrologic information. Findings were compared with engineering criteria that are currently accepted by most private and public agencies engaged in dam design, construction, and operation.

### FINDINGS AND EVALUATION

Cataract Creek Dam is owned by the State of Montana and is used for storage of irrigation waters. It is operated by the Cataract Water Users Association. The 80-foot-high earth dam impounds 1,800 acre-feet of water at top of dam, elevation 6360 feet National Geodetic Vertical Datum (NGVD), formerly Mean Sea Level (MSL).

On the basis of criteria in U.S. Army Corps of Engineers Recommended Guidelines for Safety Inspection of Dams (Ref. 1), the project is intermediate in size. The dam is located such that its failure would endanger many lives (10+ residences), cause extensive property damage in the town of Pony, and raise the water surface elevation of downstream Willow Creek Dam. Therefore, the project is classified as having a high (Category 1) downstream hazard potential. Inspection criteria (Ref. 1) recommend that an intermediate-sized project with a high downstream hazard potential be capable of safely handling the probable maximum flood (PMF) as the spillway design flood. The PMF is the flood expected from the most severe combination of meteorologic and hydrologic conditions that is reasonably possible in the region.

An estimated PMF was developed for the 6-square-mile drainage basin. Refinement of the estimate may either increase or decrease the final flood characteristics. The estimated PMF resulting from the 72-hour general storm has a volume of 6,100 acre-feet and a peak flow of 29,900 c.f.s. Routing of the estimated PMF was started with the reservoir at spillway approach channel elevation 6,353 feet NGVD. Routing of the general storm PMF indicates that the dam is overtopped

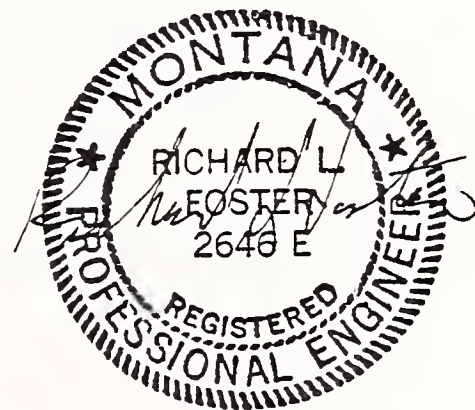


during the PMF when 27 percent of the total flood volume enters the reservoir. The dam is constructed of materials that would quickly erode and rapidly fail when overtopped by floodwaters. Such a failure would endanger the lives of many people and cause extensive property damage. Because of the seriously inadequate spillway capacity, Cataract Creek Dam does not conform to inspection guidelines with respect to safely handling the recommended spillway design flood. Because the project cannot safely handle one-half of the probable maximum flood, it is considered unsafe.

There is insufficient information on foundation conditions, embankment strengths, and water levels in the dam for evaluation of embankment stability. However, it is our preliminary judgment that the dam may conform with inspection guidelines stability criteria, provided the phreatic surface is controlled by the downstream drains.

#### RECOMMENDATIONS

A downstream warning plan, for use in the event of possible dam overtopping or structural failure, must be developed and immediately placed in operation. Inspect the low-level outlet conduit. Monitor future erosion damage in spillway discharge channel to ensure damage does not endanger the dam and make modifications, if necessary, to protect the dam. Conduct more detailed hydrologic and hydraulic routing studies to better determine the downstream hazard and required spillway capacity, and modify the project as studies indicate. Conduct stability analyses for static and earthquake loading conditions, using field and laboratory data, as appropriate.



Richard L. Foster  
Professional Engineer



## PERTINENT DATA

### 1. GENERAL

|                             |   |
|-----------------------------|---|
| Federal ID No.              | MT-5  |
| Owner                       | State of Montana                                  |
| Operator                    | Cataract Water Users Association                  |
| Date Constructed            | 1959  |
| Purpose                     | Irrigation, Recreation                            |
| Location                    | Sec. 23, T2S, R3W,<br>Principal Meridian          |
| County, State               | Madison, Montana                                  |
| Watershed                   | Cataract Creek, a North<br>Willow Creek Tributary |
| Downstream Hazard Potential | Category 1 (High)                                 |
| USGS Quadrangle             | Harrison  |

### 2. RESERVOIR

|   |                 |
|---|-----------------|
| Surface Area at<br>Spillway Crest                         | 45 acres        |
| Drainage Area   | 6 square miles  |
| Storage at Spillway<br>Crest, Elevation 6353<br>feet NGVD | 1,478 acre-feet |
| Storage at Dam Crest,<br>Elevation 6360 feet<br>NGVD      | 1,800 acre-feet |
| Surcharge Storage   | 322 acre-feet   |

### 3. SPILLWAY

|      |  |
|------|--|
| Type | Uncontrolled, unlined,<br>open channel |
|------|--|



|   |  |
|---|--|
| Bottom Width                            | 20 feet  |
| Length                                  | 720 feet   |
| Crest Elevation                         | 6353 feet NGVD   |
| Capacity with Reservoir<br>at Dam Crest | 1,250 c.f.s.   |
| 4. <u>OUTLET WORKS</u>                  |  |
| Control Tower                           | 4.83-foot-diameter<br>dry well   |
| Conduit                                 | 30-inch horseshoe-shaped;<br>reinforced concrete   |
| Conduit Length                          | 390 feet   |
| Valves                                  | One 30-inch-diameter<br>emergency gate valve<br><br>One 30-inch-diameter<br>operating gate valve |
| Capacity with Reservoir<br>at Dam Crest | 160 c.f.s.   |
| 5. <u>DAM</u>                           |  |
| Type                                    | Rolled earth with centered<br>impervious core  |
| Length                                  | 775 feet   |
| Crest Width                             | 20 feet  |
| Crest Elevation                         | 6360 feet NGVD   |
| Hydraulic Height (Crest<br>to Toe)      | 80 feet  |
| Upstream Slope                          | 1 V on 3 H   |
| Downstream Slope                        | 1 V on 2 H   |



## CHAPTER 1 BACKGROUND

### 1.1 INTRODUCTION

#### 1.1.1 Authority and Scope

This report summarizes the Phase I inspection and evaluation of Cataract Dam, owned by the State of Montana.

The National Dam Inspection Act, Public Law 92-367 dated August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to conduct safety inspections of non-Federal dams throughout the United States. Pursuant to that authority, the Chief of Engineers issued "Recommended Guidelines for Safety Inspection of Dams" in Appendix D, Volume 1 of the U.S. Army Corps of Engineers' Report to the United States Congress on "National Program of Inspection of Dams" in May 1975.

The recommended guidelines were prepared with the help of engineers and scientists highly experienced in dam safety from many Federal and state agencies, professional engineering organizations, and private engineering consulting firms. Consequently, the evaluation criteria presented in the guidelines represent the comprehensive consensus of the engineering community.

Where necessary, the guidelines recommend a two-phased study procedure for investigating and evaluating existing dam conditions so deficiencies and hazardous conditions can be readily identified and corrected. The Phase I study is:

- (1) A limited investigation to assess the general safety condition of the dam.
- (2) Based upon an evaluation of the available data and a visual inspection.
- (3) Performed to determine whether any needed emergency measures and/or additional studies, investigations, and analyses are necessary or warranted.
- (4) Not intended to include extensive explorations or analyses, or to provide detailed alternative correction recommendations.

The Phase II investigation includes all additional studies necessary to evaluate the safety of the dam. Included in Phase II, as required, should be additional visual inspections, measurements, foundation exploration and testing, material testing, hydraulics and hydrologic analyses, and structural stability analyses.



The authority for the Corps of Engineers to participate in the inspection of non-federally owned dams is limited to Phase I investigations, except for situations of extreme emergency. In these cases the Corps may proceed with Phase II studies, but only to the extent needed to answer serious questions relating to dam safety that cannot be answered otherwise. The two phases of investigations outlined above are intended only to evaluate project safety and do not encompass in scope the engineering required to perform design or corrective modification work. Recommendations contained in this report may be for either Phase II safety analysis or detailed design study for corrective work.

The responsibility for implementing of the Phase I recommendations or initiating the Phase II studies rests with the State of Montana. It should be noted that nothing contained in the National Dam Inspection Act, and no action or failure to act under this Act shall be construed (1) to create liability in the United States or its officers or employees for the recovery of damage caused by such action or failure to act or (2) to relieve an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam.

#### 1.1.2 Purpose

The purpose of the inspection and evaluation is to identify conditions that threaten public safety, so that they may be corrected promptly by non-Federal interests.

#### 1.1.3 Inspection

The findings and recommendations in this report were based on visual inspection of the project and on a detailed review of available plans, specifications, and design analyses. Inspection procedures and criteria were those established by the Recommended Guidelines for Safety Inspection of Dams (Ref. 1).

Personnel present during the May 21, 1979, inspection included:

Richard D. Eckerlin, Geologist, Corps of Engineers

Larry Tegg, State of Montana Department of Natural Resources and Conservation

Tom Fergeson, State of Montana Department of Natural Resources and Conservation



CH2M HILL personnel who participated in the field inspection and contributed to this report were:

Miles C. Bubenik, Geotechnical Engineer, Team Leader

Jerry Jacksha, Geotechnical Engineer

Loren Bottorff, Hydrologist/Hydraulics Engineer

This report has been reviewed by the State of Montana Department of Natural Resources and Conservation, and their comments are attached in Appendix A.

## 1.2 DESCRIPTION OF PROJECT

### 1.2.1 General

Cataract Reservoir and Dam are located on Cataract Creek, a tributary of North Willow Creek, in Madison County, Montana, approximately 2 miles southwest of the town of Pony (see Photo 1 and Plate 1). The project's Federal identification number is MT-5. The 80-foot-high earth dam impounds 1,800 acre-feet at dam crest, elevation 6360 feet NGVD. Based on a visual reconnaissance and engineering judgment, approximately 10 residential homes, roads, miscellaneous property and the reservoir surface elevation of downstream Willow Creek Dam would be affected by a sudden breach of Cataract Dam. On the basis of this information and in accordance with the recommended guidelines, the project size is classified intermediate and the downstream hazard potential is high (Category 1).

The 45-acre reservoir is used for irrigation storage. Although the project is owned by the State of Montana, operation and maintenance are performed by the Cataract Water Users Association.

The 720-foot-long spillway discharge channel and drop structure is located well behind the right abutment, as shown in Photos 1, 8, and 9, and on Plate 2. A 30-inch horseshoe-shaped outlet with two 30-inch-diameter gates and gate controls at the dam crest is used for irrigation releases (see Plate 6 and Photos 5 and 6).

### 1.2.2 Regional Geology and Seismicity

The information in paragraphs 1.2.2. and 1.2.3. was obtained from a memorandum by R. D. Eckerlin (Ref. 5).

Cataract Dam is located on Cataract Creek, which is situated in the northeastern part of the Tobacco Root Mountains,



within the northern Rocky Mountains' physiographic province. The range covers about 500 square miles and forms the divide between the Madison River Valley on the east and the Jefferson River Valley on the west. The Tobacco Root Mountains rise as much as 5,600 feet above the adjacent valley floors.

The Tobacco Root Mountains are rugged, composed mostly of Precambrian igneous and metamorphic rocks that have been dissected by stream erosion and modified by alpine glaciation. The mountains are flanked in places by greatly deformed layers of Paleozoic and Mesozoic sedimentary rocks including limestones, sandstones, and mudstones. Cretaceous granite (quartz monzonite), composing the Tobacco Root Batholith, intruded the center of this range while the range was rising about 70 million years ago. The Tobacco Root Batholith, occupying approximately 100 square miles, is elongated in the northwest direction. The batholithic contact with the Precambrian crystalline gneisses and schists is located within 1 mile northeast of the dam. Cataract Creek occupies a wide, U-shaped valley modified by glaciation. An abrupt passage from glaciated to unglaciated topography occurs just above the town of Pony. Morainal debris is responsible for much of the rough and hummocky surface of the mountain valley floor. Large accumulations of sand, gravel, and boulders in the form of a terminal or recessional moraine occur at the dam. The dam lies in a zone that is susceptible to major earthquake damage, and it is estimated that the dam experienced a 0.2g bedrock acceleration during the 1959 Hebgen Lake earthquake.

In accordance with the Guidelines Seismic Zone Map (Ref. 1), the site is in Seismic Zone 3. The seismic probability of Zone 3 is one of potential for major damage and is based on known distribution of damaging earthquakes. Although the zone map is based on a known distribution of damaging earthquakes, it does not necessarily reflect accurate or adequate seismic design parameters for this site.

### 1.2.3 Site Geology

State of Montana records indicate that both the dam foundation and borrow areas were investigated by drill holes and test pits; however, the information is no longer available.

Cataract Dam is founded on both glacial sediments and granitic bedrock. The left abutment consists of massive, relatively impervious granitic rock (see Photos 2 and 3), and the right abutment consists of a recessional moraine composed of silty sand, sand, gravels, and boulders (see Photo 8).



#### 1.2.4 Design and Construction History

The State of Montana acquired the necessary right-of-way in public lands required for the reservoir in 1958 and constructed the dam in the summers of 1958 and 1959. Design, preparation of plans and specifications, and construction supervision were performed by the State of Montana.

Available investigative information consisted of a few density and gradation tests on construction materials. There is no information on the shear strength of foundation or embankment materials, and there is no stability analysis on file. In addition, there is little information on hydrology or hydraulics. The file contains a good record of foundation grouting conducted in 1959 and 1960. There is no information on the need for grouting or the results with respect to seepage quantities.



## CHAPTER 2 INSPECTION AND RECORDS EVALUATION

### 2.1 HYDRAULICS AND STRUCTURES

#### 2.1.1 Spillway

The spillway for Cataract Creek Dam is located in the recessional moraine of the right abutment. Approximately 160 feet of approach channel leads from the reservoir to the uncontrolled concrete spillway structure. Approximately 720 feet of discharge channel leads from the spillway structure to Cataract Creek (see Plate 4 and Photo 8). The spillway has operated only once, in July 1975, since the project was completed in 1959.

The unlined spillway approach channel (Photo 8) is a trapezoidal section with 1 V (vertical) on 1.5 H (horizontal) side slopes and a bottom width varying from 15 to 18 feet. The channel invert is nearly level. A few rocks (1-foot in diameter) and some small brush are scattered along the length of the channel. No erosion was observed. The spillway has no log boom, but very little debris was observed in the reservoir or along its shore.

The concrete spillway is a trapezoidal section (Plate 3) with 1 V on 1.5 H side slopes and a bottom width of 20 feet. The crest section is 10 feet in length and is at elevation 6352.4 feet NGVD, approximately 0.6 feet lower than the high point of the approach channel. The crest section connects with a 42-foot-long trapezoidal (1 V on 1.5 H) concrete chute with a bottom slope of 1 V on 4 H. The chute ends at a 6-foot-long trapezoidal (1 V on 1.5 H) concrete stilling basin (Photo 9). All concrete appeared in good condition.

The unlined spillway discharge channel is a trapezoidal section with 1 V on 1.5 H side slopes and a bottom width varying from 15 to 20 feet. Riprap just downstream of the stilling basin does not appear adequate to prevent scouring because of incomplete energy dissipation during high discharges, which is common to trapezoidal stilling basins. No erosion of this area was observed, as the spillway has operated only at low discharges. Approximately 250 feet downstream of the concrete spillway structure, channel erosion from the 1975 spillway discharges was observed. The channel slope upstream from this point is approximately 2 percent, but the channel steepens downstream. The channel ends on the ridge approximately 40 feet higher in elevation



than Cataract Creek. Spillway discharges have caused heavy erosion of the fine material and have left a pile of large rock and fallen trees. The observed spillway erosion is sufficiently removed from the dam and is not serious at this time; however, the erosion requires monitoring.

The discharge rating for the spillway was developed by assuming that critical depth occurs at the concrete spillway crest. Backwater effects were computed for the approach channel with a Manning's "n" of 0.025. The maximum discharge capacity of the spillway with the reservoir at the top of the dam, elevation 6360 feet NGVD, was estimated to be 1,250 c.f.s. The spillway rating curve is presented on Plate 5.

#### 2.1.2 Outlet

The outlet works for Cataract Creek Dam is located about 180 feet from the left abutment. The intake structure could not be examined at the time of the inspection because of the high reservoir water surface level, but construction plans show it is a pair of converging wing walls covered by a trashrack. The concrete conduit is a 30-inch-diameter, straight-legged horseshoe section approximately 390 feet in length. A gate tower is located approximately 195 feet downstream from the intake structure. The conduit has a slope of 0.038 from the intake structure to the gate tower and 0.011 from the gate tower to the outlet structure.

The control for the 30-inch-diameter emergency gate valve is located at the bottom of the tower. The control for the 30-inch-diameter operating gate valve is located at the top of the tower near the crest of the dam and appeared to be in good condition (see Photo 5). The control handle is locked to the control housing. A wooden deck on the top of the gate tower is bolted down to prevent easy access to the tower.

The outlet structure at the downstream toe of the dam consists of a pair of divergent wing walls (see Photo 6). The structure was in good condition and only minor erosion was observed downstream. The conduit was not inspected because of its small diameter.

The outlet works was rated with both valves fully open. A Manning's "n" of 0.013 was used to estimate friction losses with the conduit flowing full. The maximum discharge capacity of the outlet works, with the reservoir at the top of the dam, elevation 6360 feet NGVD, was estimated to be 160 c.f.s.



### 2.1.3 Freeboard

The freeboard on the dam at the time of the inspection was 40 feet, and the reservoir was approximately 33 feet below the spillway approach channel. A normal high water mark was observed 18 feet below the spillway crest, but historical high water was slightly above spillway crest (July 1975). The spillway approach channel is 7.0 feet lower than the low point on the dam crest.

The crest of the dam varies about 0.9 of a foot over its 775-foot length. The fetch for wind-generated waves is less than 2,000 feet, and wave runup on the embankment is estimated to be about 3 feet. The freeboard for normal conditions is adequate to prevent overtopping by wind waves.

## 2.2 HYDROLOGY, CLIMATOLOGY, AND PHYSIOGRAPHY

### 2.2.1 General

The climate of the area is continental in nature, characterized by warm summers and cold winters. The nearest climatological station (elevation 5500 feet NGVD) is at Pony, about 4 miles northeast of the center of the basin; however, only 19 years of records are available. A climatological station is also located at Norris, about 15 miles southeast of the center of the Cataract Creek Dam drainage basin. Mean annual precipitation at the Norris station is 18.5 inches, with 52 percent falling in April through July. Mean February precipitation is 0.65 inches. Mean annual precipitation on the Cataract Creek Dam drainage basin is probably near 14 inches. Mean annual temperature at Norris is 47 degrees Fahrenheit (F), mean January temperature is 25.9 degrees F, and mean July temperature is 70.3 degrees. Temperatures in the Cataract Creek Dam drainage basin probably average about 12 degrees cooler than Norris. Summer temperatures can exceed 100 degrees F, and winter temperatures can dip well below 0 degrees F. Winters have few extended cold spells; periods of warm "chinook" winds occur between cold spells.

The drainage basin area for Cataract Creek Dam is 6 square miles. The basin is steep and mountainous, with basin elevations varying from 6360 feet NGVD at the dam to 10,600 feet NGVD at Mount Jefferson on the southwestern boundary. Cataract Creek, the main inflow creek to the reservoir, has an average gradient of 770 feet per mile. Approximately 60 percent of the basin is heavily forested and 40 percent is open. There are no USGS stream gages in the basin or in surrounding basins. Parshall flumes (Photo 7) were installed to measure reservoir inflow and outflow, but they are not maintained or read regularly. There is no reservoir staff gage.



Mason Lake Dam (MT-1272) is located within the Cataract Creek Dam drainage basin. The earth embankment is 9 feet high and impounds 100 acre-feet of water.

#### 2.2.2 Reservoir Storage and Spillway Discharge

The reservoir has a surface area of 45 acres and a storage of 1,478 acre-feet at spillway approach channel elevation 6353 feet NGVD. Approximately 322 acre-feet of surcharge storage is available in the reservoir between the spillway crest and the dam crest. The spillway discharge with the reservoir at the dam crest is 1,250 c.f.s., about 100 acre-feet per hour.

#### 2.2.3 Estimated Probable Maximum Flood

The probable maximum flood (PMF) is the flood expected from the most severe combination of critical meteorologic and hydrologic conditions that is reasonably possible in the region. An estimate of the PMF was made during this dam safety analysis and was routed through the reservoir.

The procedure contained in the U.S. Weather Bureau's Technical Paper 38 (Ref. 2) was used to compute the probable maximum precipitation (PMP). This storm produces 11 inches in 6 hours and 15.2 inches in 24 hours. The 72-hour precipitation was estimated to be 115 percent of the 24-hour precipitation value, 17.5 inches.

Frozen ground and no infiltration losses were assumed during the entire flood. A base flow of 90 c.f.s. was used for the entire flood. No snowmelt was used during the PMF.

A triangular unit hydrograph for a 15-minute rainfall duration was developed for the 6-square-mile drainage basin by procedures outlined in Design of Small Dams (Ref. 3). A curvilinear fit of the triangular unit hydrograph was used. The PMP was applied to the unit hydrograph by means of the computer program HEC-1 (Ref. 4). This estimate of the PMP produced a flood with a peak of 29,900 c.f.s. and a volume of 6,100 acre-feet.

#### 2.2.4 Flood Routing

The PMF was routed through the reservoir by using the computer program HEC-1 (Ref. 4). The reservoir level was assumed to be at the spillway crest at the beginning of the PMF, and the outlet valves were assumed to be fully open. The routing shows that the dam will be overtopped during the PMF, when approximately 27 percent of the total flood volume enters the reservoir.



## 2.3 GEOTECHNICAL EVALUATION

### 2.3.1 Dam

The 80-foot-high zoned earthfill dam is 775 feet long and has a crest width of 20 feet (see Plate 7). The upstream slope is 1 V on 3 H and the downstream slope is 1 V on 2 H. The central impervious earth core has a 15-foot width at dam crest elevation 6360 feet NGVD, and both the upstream and downstream core slopes are 0.5 V on 1 H. A cutoff trench on dam centerline has a bottom width of 20 feet at a depth of 10 feet below the original ground surface. The impervious core is tied to a 10-foot-thick impervious blanket that extends to the upstream toe, and the impervious core is protected both upstream and downstream by 10-foot-wide sand filters. There is insufficient information on gradation of filter, core, and the adjacent soil to permit checking filter criteria. The construction specifications for the upstream shell material state that the material required was to be a pit run sand, gravel, or rock with no limitation on grading. The downstream shell material required by the specifications was sand, gravel, and rock. However, the specifications did not restrict the percentage of fines or the materials passing the No. 200 mesh sieve. According to specifications, all materials were placed in lifts and compacted. If the dam were to overtop, the silt core, sand filters, and sand and gravel shells would rapidly erode, resulting in failure. A typical section of the dam, obtained from construction as-built drawings, is shown on Plate 7, and a centerline profile, also obtained from construction as-built drawings, is shown on Plate 8. An interior 8-inch concrete pipe drain is located immediately downstream of the downstream filter (see Plate 7).

Based on the as-built drawings, the outlet control tower is founded on rock as is the greater length of the outlet conduit.

Borrow materials for embankment construction were obtained from within the reservoir area, spillway excavation, and left abutment.

The upstream embankment slope is adequately protected from erosion caused from wave attack by a layer of large riprap (see Photos 1 and 2). The height of wind-generated waves is limited by the short fetch and is estimated to be less than 2 feet.

There are a few scattered trees and some brush on the downstream slope, as shown in Photos 3, 4, and 6.



### 2.3.2 Foundation, Conditions, Seepage, and Drainage

As stated in paragraph 1.2.3 Site Geology, the left abutment foundation is massive granite rock, which is relatively impervious. The foundation, beginning at station 2 + 50 and continuing to the end of the dam and right (south) abutment, is recessional moraine, consisting of sands, gravels, and boulders. Preliminary study of information on reservoir water levels and storage in State of Montana files, collected in 1960 by William D. Morton and included in a report on history of grouting, suggests that the seepage quantity is about 1,100 gpm at pool levels about 25 feet below spillway crest. Seepage first emerges on the right abutment approximately 500 feet downstream of the dam and extends along the slope for several hundred feet. At the time of our inspection, with water level at 6320 feet NGVD (40 feet below dam crest), there was no seepage along the abutments or downstream toe. Inspections by the State of Montana indicate seepage occurs in the valley floor near the dam and downstream right abutment slope at the higher reservoir levels. However, W. D. Morton reported that on June 21, 1960, with the pool at elevation 6335 feet NGVD, there was no abutment or toe seepage.

A grouting program was conducted in 1959 and 1960 in an attempt to reduce the significant underseepage because losses reduced water storage for irrigation. The reasons for selecting grouting as a means of seepage control are unknown. The record shows that 5,000 sacks of bentonite and 2,500 sacks of cement were pumped into 24 holes located on dam centerline (some of which were 160 feet deep), using pressures that varied from 0 to 160 p.s.i. The grouting record repeatedly refers to grout breaking out in the ground between holes and returning from adjacent holes, which indicates that the grouting was actually splitting the embankment. Grouting probably did little harm to the embankment, except the record states that on at least two occasions, grout was observed flowing from the 8-inch interior drain. Because little more than a trickle was observed flowing from the drain at the time of our inspection, and the hydraulic head above the elevation of the drain was about 30 feet, the drain may be plugged with grout. If the interior drain is plugged, it may result in a raised downstream phreatic surface and a corresponding decrease in stability, unless the downstream shell is sufficiently pervious to provide drainage.

It is not known whether grouting was accomplished with the aid of piezometric observations.



The embankment design used an impervious upstream foundation blanket, which functions to increase the seepage path from about 20 feet to about three times the dam height at any point.

A permeability test on the recessional moraine deposit of the right abutment was conducted by the State of Montana and is of interest. The test indicated that the moraine has a permeability coefficient of  $1 \times 10^{-5}$  ft/min. This value, together with the location of the current seepage, suggests that some portions of the moraine are relatively impervious.

### 2.3.3 Stability

Study of available information suggests that if the downstream sand filter, interior drain, and downstream shell function to lower the phreatic surface, as planned by the design engineer, stability under static loadings may conform to the recommended guidelines. However, the grouting records suggest the interior drain may be plugged, and if this is true, stability may not conform to the guidelines because of a high downstream phreatic surface. There are no piezometers in the dam to determine the position of the phreatic surface.

Sufficient information is not currently available for evaluation of embankment stability.

## 2.4 PROJECT OPERATION AND MAINTENANCE

The facility is owned by the State of Montana and is operated by the Cataract Water Users Association.

### 2.4.1 Dam

Some small trees and brush were growing on the downstream face of the embankment and in the spillway channel, indicating a lack of recent maintenance. There is no periodic maintenance plan. However, the State of Montana DNRC conducts annual inspections of the facility and makes appropriate recommendations for maintenance and repairs. The DNRC has made attempts to stop the seepage from the reservoir.

### 2.4.2 Reservoir

There is almost no operation of the reservoir. The outlet works usually remains shut and seepage from the reservoir makes up the flow in Cataract Creek. At times, the outlet may be slightly opened to supplement the reservoir seepage. Because the reservoir provides no reasonable guarantee of water delivery, the facility is of little value to the water users.



#### 2.4.3 Warning System

There is no formal warning plan for use in the event of impending dam failure.



## CHAPTER 3 FINDINGS AND RECOMMENDATIONS

### 3.1 FINDINGS

Visual inspection of the dam, supplemented by analysis of the project in terms of the recommended guidelines' performance standards, resulted in the following findings.

#### 3.1.1 Size, Hazard Classification, and Safety Evaluation

In accordance with the recommended guidelines (Ref. 1), the project is classified as intermediate in size and has a high (Category 1) downstream hazard potential. The recommended spillway design flood for this project is 100 percent of the PMF. Because the project can safely handle only 27 percent of the PMF without overtopping and causing the dam to fail, Cataract Creek Dam is considered unsafe until the recommended actions (section 3.2) are completed.

#### 3.1.2 Embankment Dam

A visual inspection of Cataract Dam revealed no longitudinal or transverse cracking, as well as no embankment, abutment, or toe seepage. Freeboard at time of inspection was 40 feet, which corresponds to reservoir elevation 6320 feet NGVD.

The downstream slope was uniform with no irregularities. A few scattered trees and brush were present on the downstream slope, abutments, and toe area.

Grouting conducted in 1959 and 1960 using high pressures split the embankment and may have plugged the interior drainage system, as flow from the concrete pipe, under a 30-foot hydraulic head, was only a trickle. The grouting was ineffective in reducing seepage quantities in an amount sufficient to fully use the available storage. Seepage, estimated at about 1,100 gpm, was emerging about 500 feet downstream of the right abutment. In our judgment, this seepage is unrelated to seepage near the dam embankment.

Insufficient information is currently available for evaluation of embankment stability.

Riprap on the upstream slope adequately protects against erosion.



### 3.1.3 Spillway and Reservoir Capacity

The reservoir has a surface area of 45 acres and a storage of 1,478 acre-feet at the spillway approach channel, elevation 6353 feet NGVD. Approximately 322 acre-feet of surcharge storage is available in the reservoir between spillway crest and dam crest. The discharge of the spillway, with the reservoir at the dam crest, is 1,250 c.f.s. Inspection guidelines (Ref. 1) recommend that a dam of intermediate size and high downstream hazard potential be capable of safely handling the PMF. An estimate of the PMF indicates that the dam will be overtopped when 27 percent of the total flood volume enters the reservoir. Because the resulting rapid failure would significantly increase potential loss of life downstream from the dam, spillway capacity is seriously inadequate.

### 3.1.4 Outlet Works

The outlet works appeared in good condition. The conduit was not inspected because of its small size.

### 3.1.5 Operations and Maintenance

The State of Montana DNRC conducts annual inspections of the facility and makes appropriate recommendations for maintenance and repairs. The DNRC has made attempts to stop the seepage from the reservoir. The outlet works usually remains shut, and seepage from the reservoir makes up the flow in Cataract Creek. Because the reservoir provides no reasonable guarantee of water delivery, the facility is of little value to the water users. There is no formal downstream warning plan for use in the event of impending dam failure.

## 3.2 RECOMMENDATIONS

The findings suggest that high priority be given the following recommendations:

1. Immediately develop, implement, and periodically test an emergency warning plan for use in the event of impending dam overtopping or structural failure.
2. Remove the few scattered trees, root systems, and brush from the embankment and toe areas. Backfill and compact all depressions.
3. Inspect the low-level outlet conduit and repair it, if required.



The above items will not make the project safe, but they will reduce risk to life and property while the following recommended actions are being taken.

4. Monitor erosion damage in the spillway discharge channel to ensure it does not endanger the dam.
5. Determine source of present right abutment seepage and underseepage by installation and observation of piezometers and study of the data. Monitor seepage as related to reservoir levels.
6. Conduct and place on file stability and seepage analyses of the dam embankment and right abutment. These analyses must be performed by qualified geotechnical engineers and be based on: seismic and static loading conditions; in situ strength properties of the embankment, foundation, and abutment materials; and phreatic surface conditions. The seismic loads must be based on an assessment of the area, and the project's response to a seismic event must be evaluated. The material strength properties must be established by drilling, sampling, and testing as appropriate, and the phreatic surface determined by installing and monitoring piezometers.
7. Conduct more detailed hydrologic and hydraulic routing studies to better determine the downstream hazard and required spillway capacity, and modify the project as studies indicate.
8. Conduct inspections of Cataract Dam at least once every 5 years by engineers experienced in dam design and construction.



## REFERENCES

1. U.S. Army Corps of Engineers, Office of the Chief of Engineers Report to the U.S. Congress, National Program of Inspection of Dams, Vol. 1, Appendix D, "Recommended Guidelines for Safety Inspection of Dams," Washington, D.C., Department of the Army, May 1975.
2. U.S. Weather Bureau, Technical Paper 38, Generalized Estimates of Probable Maximum Precipitation for the United States West of the 105th Meridian, Washington, D.C., 1960.
3. U.S. Bureau of Reclamation, "Design of Small Dams," Second Edition, 1974.
4. U.S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-1 Flood Hydrograph Package, Davis, California, January 1973.
5. R.D. Eckerlin, U.S. Army Corps of Engineers geologist, Memorandum on Cataract Dam Inspection, June 1979.



APPENDIX



DEPARTMENT OF NATURAL RESOURCES  
AND CONSERVATION  
WATER RESOURCES DIVISION



THOMAS L. JUDGE, GOVERNOR

32 SOUTHEWING

STATE OF MONTANA

(406) 449-2872

HELENA, MONTANA 59601

February 14, 1980

Department of the Army  
Seattle District, Corps of Engineers  
P.O. Box C-3755  
Seattle, Washington 98124

Attn: Mr. Ralph Morrison

Re: CH2M Hill final Dam Safety Inspection report on Cataract  
Creek Dam (MT - 5).

Dear Ralph:

We have reviewed the above referenced report and find that, with the few exceptions following, the report is satisfactory:

1. On page ii, in the second paragraph, it is stated that the dam will be overtopped during the PMF when 27 percent of the flood volume has entered the reservoir. A statement should be added as to what percentage of PMF (ordinate method) will overtop the dam.

2. The report does not establish whether or not the embankment is stable or whether or not 50 percent of the PMF (ordinate method) will overtop the dam. This would be necessary in order to make the statement in the Executive Summary that the dam is unsafe.

3. On page 17 under 2.2.4 Flood Routing, a statement should be added as to what percentage of PMF (ordinate method) will overtop the dam.

4. On page 28, under 3.1.3 Spillway and Reservoir Capacity, a statement should be added as to what percentage of PMF (ordinate method) will overtop the dam.

We thank you for the opportunity to review and comment on this report.

Sincerely,

*Richard L. Bondy*  
Richard L. Bondy, P.E.  
Chief, Engineering Bureau

RLB:LT:mb





PHOTO 1      Cataract Dam upstream slope and right abutment. Spillway approach channel at upper right corner. Note large size riprap.



PHOTO 2      View towards left abutment and impervious borrow above dam crest.





PHOTO 3      Downstream slope and left abutment  
impervious borrow



PHOTO 4      Interior drain discharges at right abutment.  
Seepage quantity was only trickle.





PHOTO 5

Operating gate control at top of  
tower near crest of dam.



PHOTO 6

Outlet structure near left abutment.





PHOTO 7      Flume downstream of outlet structure.



PHOTO 8      Spillway approach channel, concrete spillway in background.



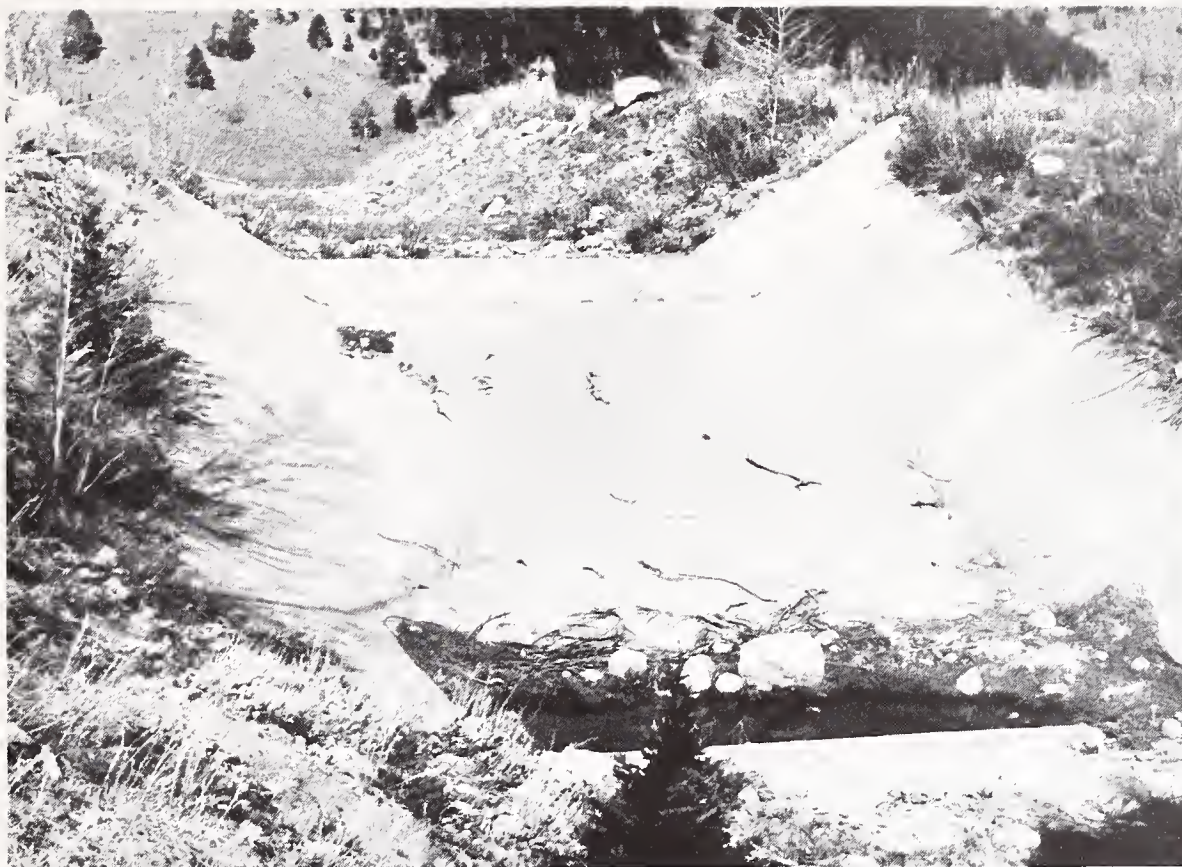


PHOTO 9      Spillway with water in stilling basin.



PHOTO 10      View downstream, Town of Pony,  
2 miles distant.



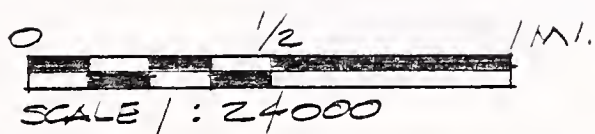
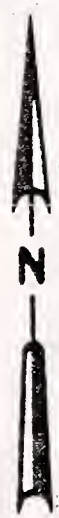
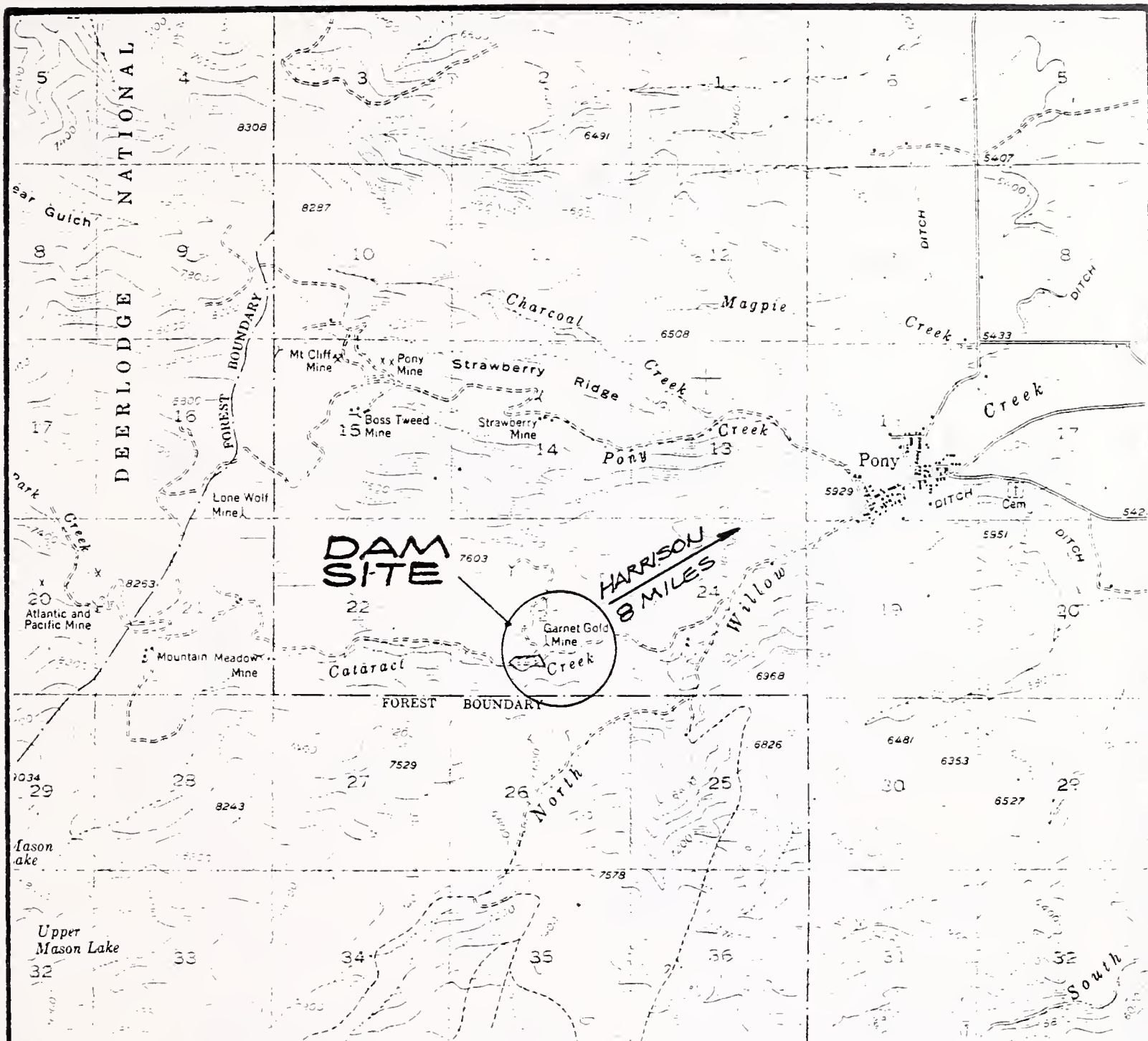
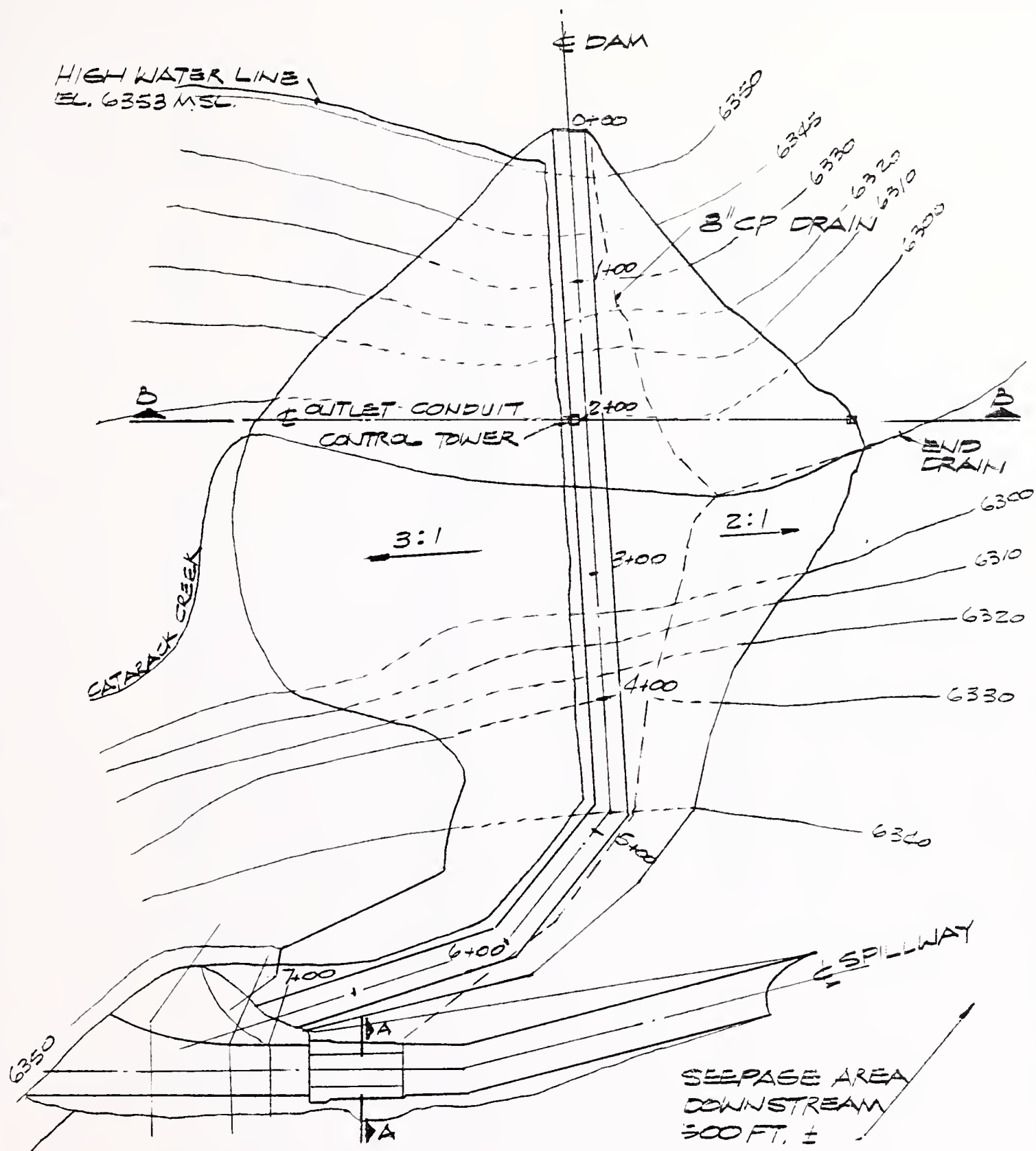


PLATE 1  
CATARACT CREEK DAM  
VICINITY MAP







PLAN  
N.T.S.

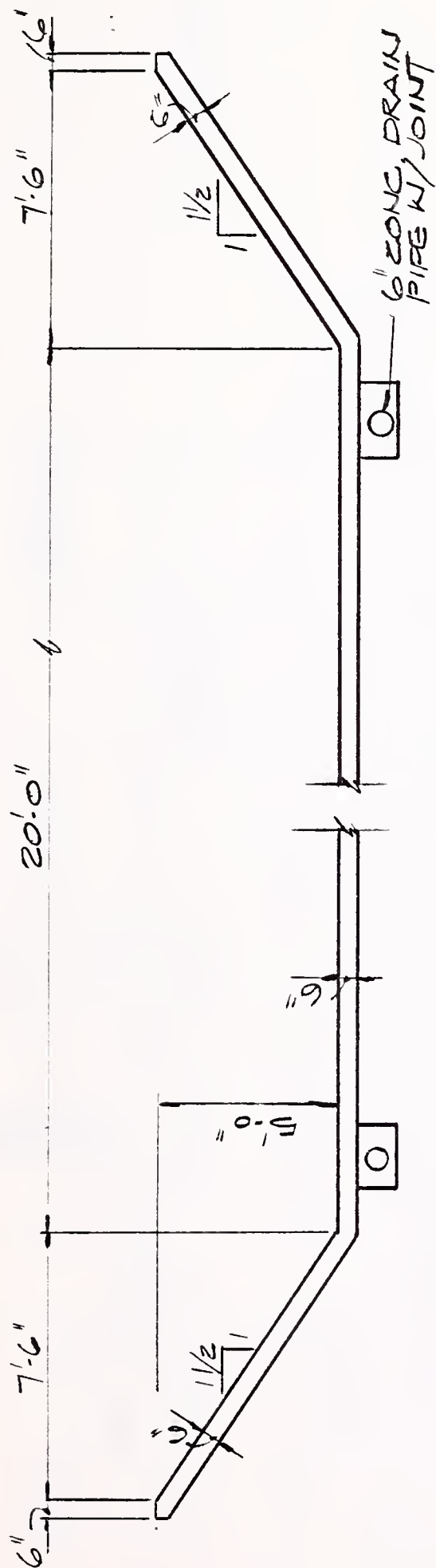
REFERENCE : CONSTRUCTION DRAWINGS  
1957

PLATE 2

CATARACT CREEK DAM  
DAM & SPILLWAY PLAN







SECTION A-A  
1/4" = 1'-0"

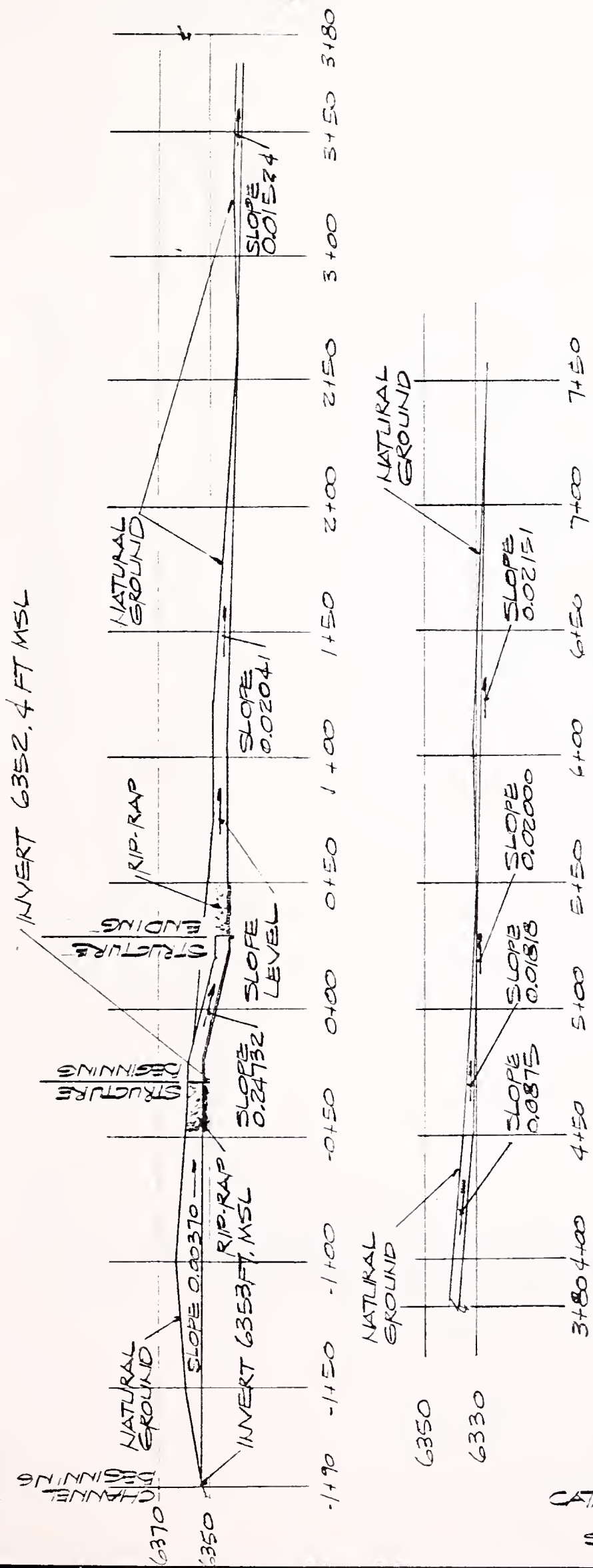
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PLATE 3

CATARACT CREEK DAM  
SPILLWAY SECTION





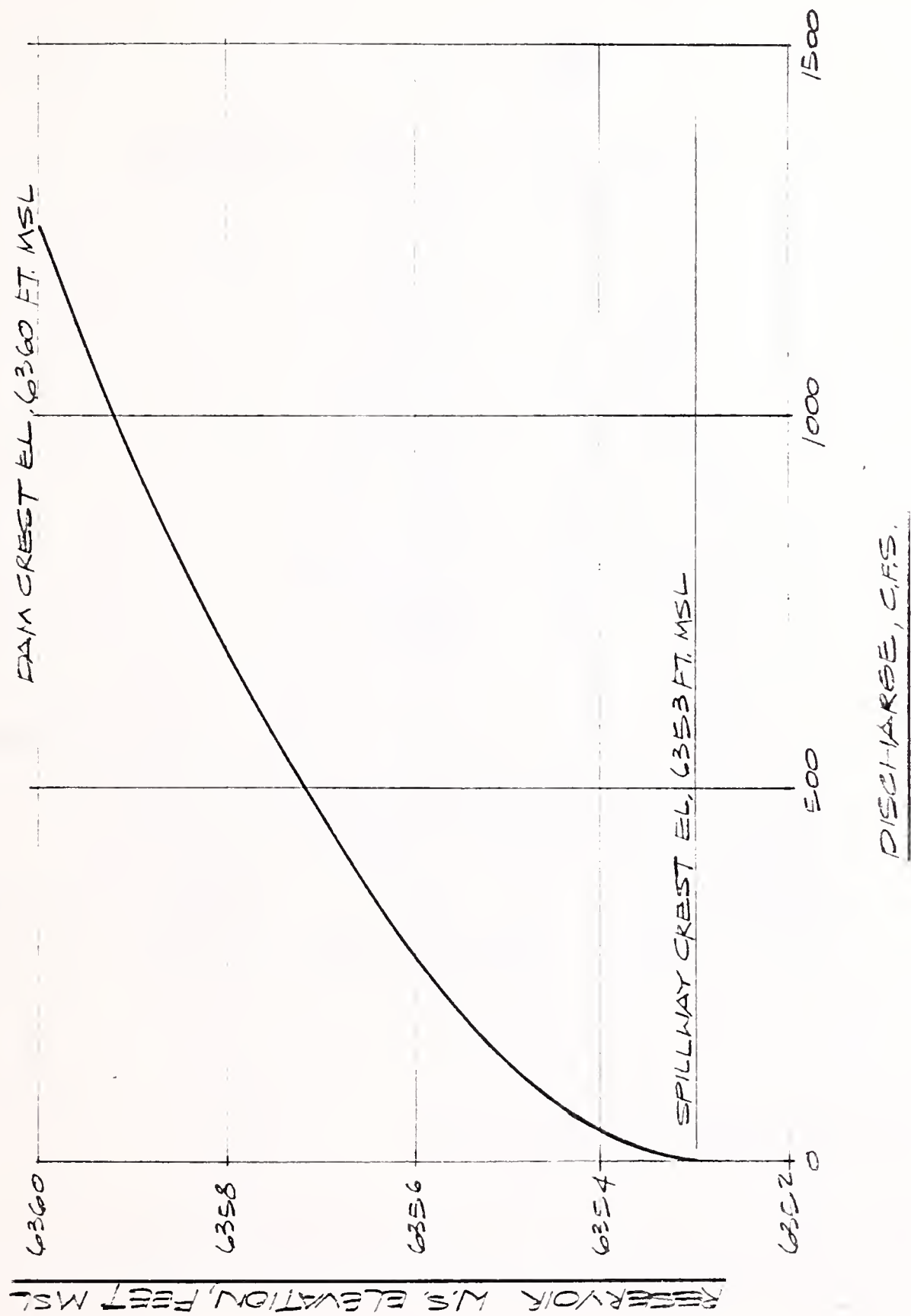


REFERENCE: CONSTRUCTION DRAWINGS - 1957

PLATE 4  
CATARACT CREEK DAM  
SPILLWAY PROFILE

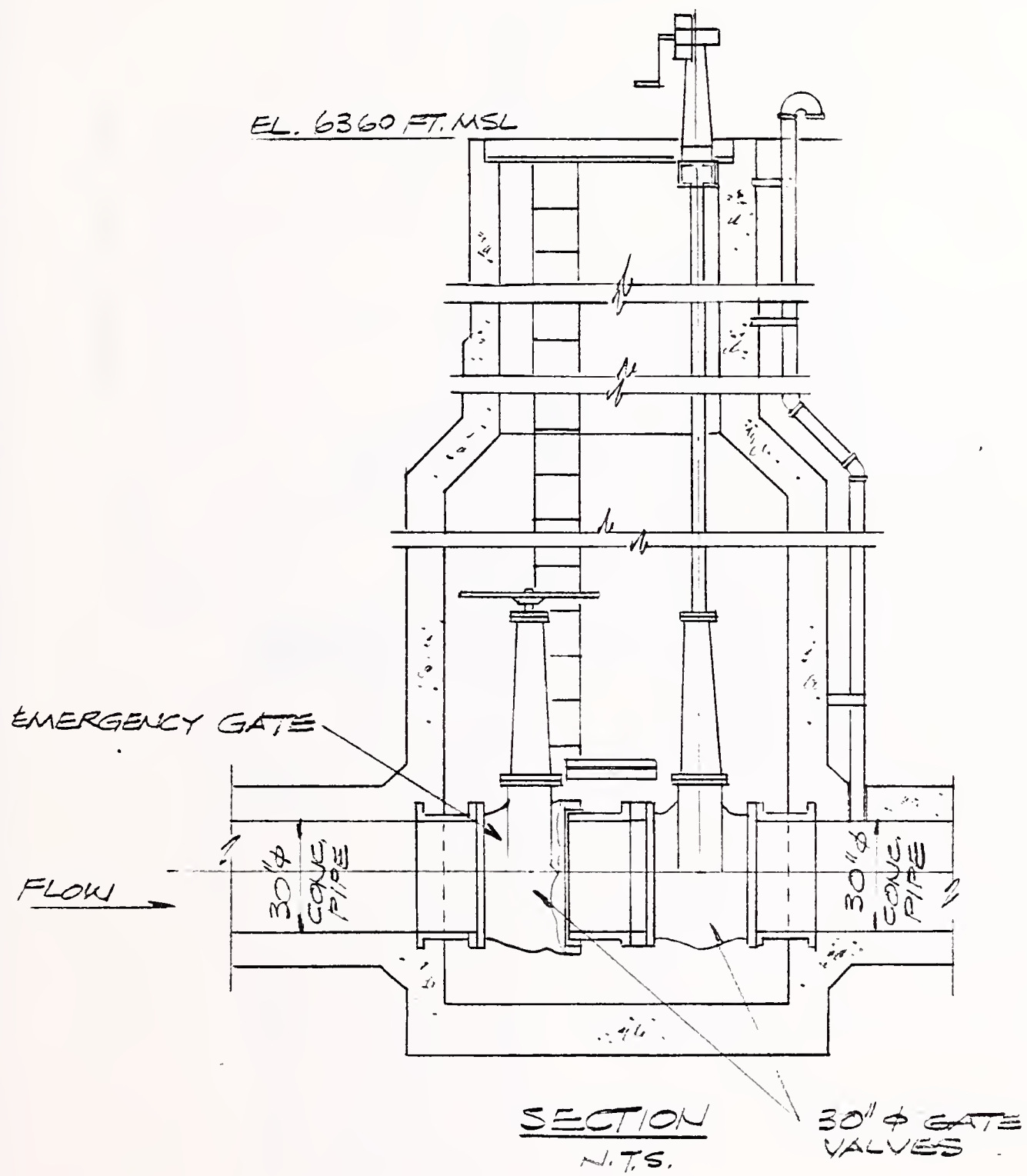






**PLATE 5**  
**CATARACT CREEK DAM**  
**SPILLWAY RATING CURVE**





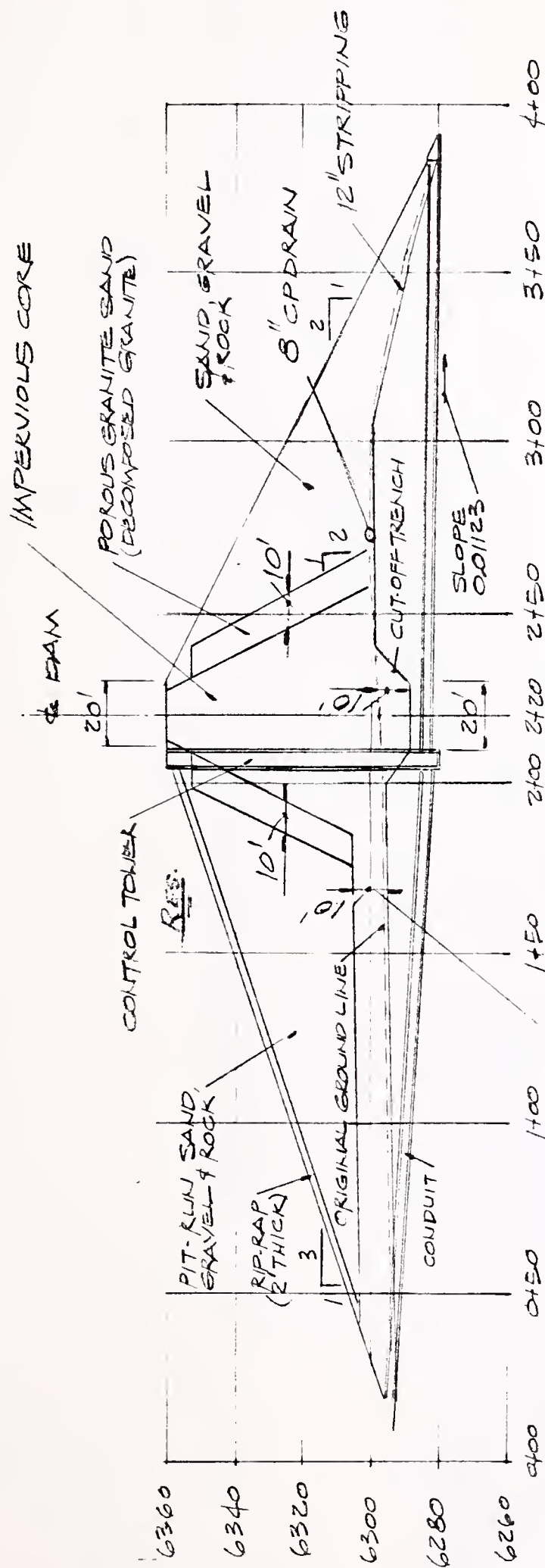
REFERENCE: CONSTRUCTION DRAWINGS - 1957

PLATE 6

CATARACT CREEK DAM  
CONTROL TOWER SECTION

CH2M  
HILL





UPSTREAM IMPERVIOUS FOUNDATION BLANKET

SECTION B-B  
N.T.S.

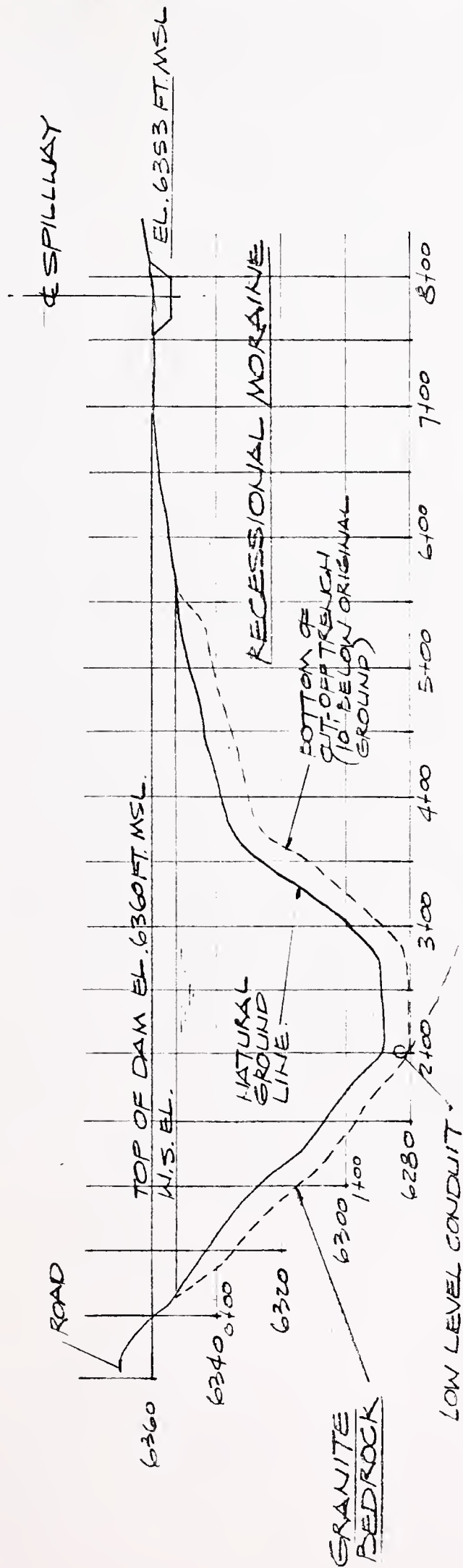
\* REFERENCE: CONSTRUCTION DRAWINGS 1957

PLATE 7

CATARACT CREEK DAM  
DAM SECTION







PROFILE

N.T.S.

REFERENCE: CONSTRUCTION  
DRAWINGS, 1957

PLATE 8  
CATARACT CREEK DAM  
DAM PROFILE





